Doc Ref. **FP1**
Appl. No. 10/501,736

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 651 531 A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number : **94307657.0**

(22) Date of filing : **19.10.94**

(51) Int. Cl.^{6} : **H04L 1/12**

(30) Priority : **29.10.93 US 146372**

(43) Date of publication of application :
03.05.95 Bulletin 95/18

(84) Designated Contracting States :
DE FR GB IT

(71) Applicant : **AT & T Corp.**
32 Avenue of the Americas
New York, NY 10013-2412 (US)

(72) Inventor : **Daly, John J.**
107 Omni Court
Neshanic Station, New Jersey 08853 (US)
Inventor : **Haisch, Herman F.**
6 Grandview Drive,
P.O. Box 29
Holmdel, New Jersey 07733 (US)
Inventor : **Kapsales, Peter**
128 Ueland Road
Red Bank, New Jersey 07701 (US)
Inventor : **Krishnamurthy, Bala**
No.6 Cambridge Court
Morganville, New Jersey 07751 (US)
Inventor : **Miska, Richard A.**
27 Joshua Drive
Belle Mead, New Jersey 08502 (US)
Inventor : **Walker, Carl E.**
321 Buchanan Boulevard
Red Bank, New Jersey 07701 (US)
Inventor : **Nordgaard, Joseph K.**
63 Lake Ave
Fair Haven, New Jersey 07704 (US)

(74) Representative : **Buckley, Christopher Simon Thirsk et al**
AT&T (UK) LTD.,
AT&T Intellectual Property Division,
5 Mornington Road
Woodford Green, Essex IG8 0TU (GB)

(54) **Communication technique employing variable information transmission rate function of quality.**

(57) A communication method wherein rate of information transfer with a given signal transmitted or received at a transceiver node (e.g. 101) is dynamically varied as a function of the relative quality of the transmission environment. The method employs a responsive buffering process (in 107) at each communication node that permits this rate to be varied somewhat independently of the rate at which information is transferred to or from the transceiver node. In a particular application, the invention permits information to be exchanged between a wireless signal (from 116) having a variable error correction bandwidth and a fixed bandwidth data stream (108,115,111).

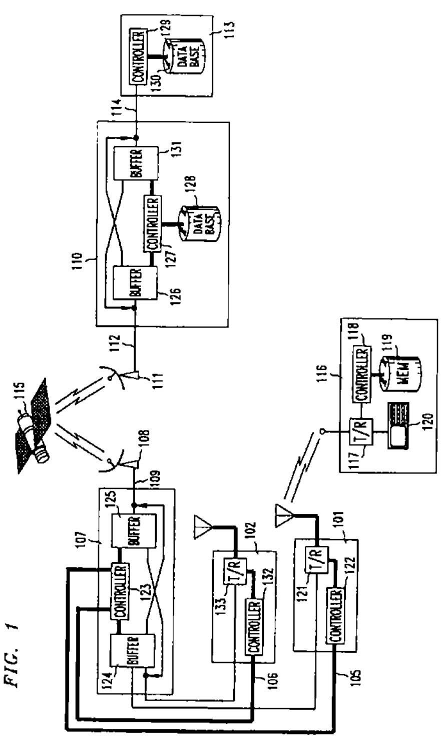


FIG. 1

EP 0 651 531 A2

Jouve, 18, rue Saint-Denis, 75001 PARIS

Background Of The Invention

For field managers, as well as field sales and service personnel, the ability to conveniently and rapidly transmit and/or receive messages to and from a central data base is essential. However, the mobile nature of these and many other occupations makes access to wireline terminals impractical, if not impossible. Modern wireless two-way messaging systems, such as commercial remote data terminal networks, are directed to supporting the mobile data messaging needs of such professionals as they travel about the coverage area of the messaging network. These networks typically operate within the frequency range reserved for cellular communications, and require a bandwidth on the order of 25 MHz.

Within such networks, users employ transportable field transceivers to contact one or more regional processors, and thereby gain access to the network and a central application host/database. Typically, as a user moves about the coverage area, signals traveling between the mobile and regional processors are subject to fading (i.e., random signal variations usually induced by atmospheric conditions and/or the surrounding topography). These variations can introduce bit errors into the data being passed to and from the mobile transceiver. The standard protocols and relatively unintelligent regional processors employed within the networks dictate that a substantial fixed portion of the transmission bandwidth be dedicated to error correction. This naturally reduces the bandwidth available to a user for sending and receiving information. The error correction afforded by this information bandwidth reduction is indeed necessary when a user is in an area where fading is evident. However, in an environment where fading is minimal or zero, successful transmission and reception of information can be accomplished with reduced error correction. If the percentage of bandwidth dedicated to error correction were to be dynamically adjusted in response to the relative fading a user was experiencing, the information bandwidth could be maximized. This type of dynamic bandwidth management is employed within certain facsimile machine protocols, so that if the telephonic connection between two facsimile machines is of high quality (i.e., induces minimal bit errors) the amount of error correction is reduced, and the bandwidth afforded to information transmission is increased. Unfortunately, current wireless two-way data networks are unable to employ dynamic bandwidth management. In order to accommodate dynamic variations in the information bandwidths of the field transceivers employed within a wireless two-way data network, the information bandwidths of the associated regional processors and central application host/database would have to be responsively varied in a similar dynamic manner. The transceivers, processors and protocols utilized within present wireless two-way data networks are simply not adapted to support such bandwidth dynamics.

Summary Of The Invention

The aforementioned problems and limitations are solved, in accordance with the principles of the invention, by providing a communication method wherein rate of information transfer with a given signal transmitted or received at a transceiver node is dynamically varied as a function of the relative quality of the the transmission environment. The method employs a responsive buffering process at each communication node that permits this rate to be varied somewhat independently of the rate at which information is transferred to or from the transceiver node. In a particular application, the invention permits information to be exchanged between a wireless signal having a variable error correction bandwidth and a fixed bandwidth data stream.

Brief Description Of The Drawing

In the drawing:

FIG. 1 shows, in simplified block diagram form, a wireless two-way messaging system incorporating a particular embodiment of the invention; and

FIG. 2 shows, in simplified block diagram form, a wireless two-way messaging system incorporating a particular embodiment of the invention.

Detailed Description Of The Invention

FIG. 1 is a simplified block diagram showing a wireless two-way messaging system incorporating a particular embodiment of the invention. As shown, base transceivers 101 and 102 are connected via information channel wirelines 103 and 104, and control wirelines 105 and 106 to regional control processor ("RCP") 107, and RCP 107 is connected to satellite hub 108 via wireline 109. Each base transceiver is adapted to receive, transmit and process radio signals having a fixed channel bandwidth B. Network Gateway Controller ("NGC") 110 is shown to be connected to satellite hub 111 by wireline 112, and to application host/database ("AH/D") 113 by wireline 114. The communication link provided by satellite hubs 108 and 111 and direct broadcast satellite 115 is referred to as the backbone message transport ("BMT") link. Field transceiver 116 is shown to be located in the vicinity of base transceiver 101. Field transceiver 116 is adapted to transmit and receive encoded radio signals having a fixed channel bandwidth B. A portion of this bandwidth, designated I, is employed to carry information, and the remainder of bandwidth B, designated E, is used to provide error correction for the information portion of the signal. Typically, forward error correction would be employed, but other coding

schemes could also be used. The system illustrated in FIG. 1 can be viewed as a communication network wherein a transmission form end to end would involve a minimum of six nodes (a field transceiver, a base transceiver, an RCP, a BMT link, an NGC and an AH/D).

For a particular method of practicing the invention, field transceiver 116 initiates a request to receive data from AH/D 113 by transmitting an encoded radio signal of bandwidth B. Such a request would include information as to the identity of the field transceiver and the particular data and AH/D being queried. As shown in FIG. 1, field transceiver 116 includes radio transmitter/receiver ("T/R") 117, controller 118, memory 119, and interface 120. Since this is an initial transmission, controller 118 would instruct transmit/receive unit 118 to employ a predetermined portion of bandwidth B for the purposes of error correction (the predetermined portion, designated E_1, would be set as a function of information retrieved by controller 118 from memory 119). The encoded signal (containing information of bandwidth B-E_1, and error correction of bandwidth E_1) would then be transmitted from T/R 117 for reception by a base transceiver.

The signal transmitted by field transceiver 116 is received and processed by base transceiver 101. Upon receipt of the signal by T/R 121, controller 122 within base transceiver 101 performs a qualitative assessment of the signal. If it is determined that present transmission environment requires a level of error correction higher than that afforded by bandwidth E_1 (i.e., radio channel quality is poor), or if an information reduction ("IR") signal is received from RCP 107, a message instructing field transceiver 116 to increase the error correction bandwidth to an appropriate level is generated by controller 122 and transmitted by base transceiver 101. Controller 118 of field transceiver 116 responds by increasing the bandwidth devoted to error correction to some value E_{1+} (where $E_{1+}>E_1$), and re-transmits the previously transmitted information at a reduced bandwidth of B-E_{1+}. All communications between field transceiver 116 and base transceiver 101 will be carried out at this increased error correction level until an assessment of the signal received at base transceiver 101 indicates that a different level of error correction (either higher or lower) is merited. If, however, the assessment of the initial signal received from field transceiver 116 indicates that the present transmission environment would tolerate signals with a lesser degree of error correction controller 122 generates a message instructing field transceiver 116 to decrease the error correction bandwidth to a value of E_{1-} (where $E_{1-}<E_1$). This message is then transmitted to field transceiver 116 by base transceiver 101; although transmission of this message may be prohibited if controller 122 receives an IR signal from RCP 107 via control wireline 105. However, assuming controller 122 is not receipt of such an IR signal, communications between field transceiver 116 and base transceiver 101 will be carried out using this decreased error correction level until an assessment of the signal received at base transceiver 101 indicates that a different level of error correction is merited, or until controller 122 receives an IR signal from RCP 107. Naturally, if the quality of the initial signal received at base transceiver 101 is found to be commensurate with the level of error correction provided by bandwidth E_1, there is no need to alter the information/error correction bandwidth proportions for future communications, and no message regarding such need be sent to field transceiver 116 until an assessment of the received signal at base transceiver 101 indicates otherwise.

Naturally, as the ratio of error correction bandwidth versus information bandwidth is altered, the rate at which base transceiver 101 receives field transceiver 116's request for data from AH/D 113 varies. As a result, the rate at which data travels from base transceiver 101 to RCP 107 along information channel wireline 103 fluctuates. The data received by RCP 107 on information channel wireline 103 is passed to wireline 109 and the BMT link (which includes satellite 115, and satellite hubs 108 and 111). RCP 107 functions to provide an intelligent buffer between the fluctuating rate data arriving on information channel wireline 103 and the fixed data rate of the BMT link. RCP 107 also embeds information reflecting the aggregate rate at which data is being collected from base transceivers, and the fullness of buffer 125, into the data stream transmitted along wireline 109.

As shown in FIG. 1, RCP 107 includes controller 123, and buffers 124 and 125. Controller 123 functions to monitor the rate at which data is being sent to and from the various base transceivers connected to buffer 124, as well as the rate at which data is being sent to buffer 125 from the BMT link. Via control wireline 105, controller 123 receives information from controller 122 regarding the rate at which data from base transceiver 101 will be sent to buffer 124. If controller 123 determines that the aggregate incoming data rate to buffer 124 is equal to the fixed rate at which data may be passed through the BMT link, the incoming data is multiplexed or packetized within RCP 107, and then passed to satellite hub 108 via wireline 109. If, however, controller 123 determines that the aggregate incoming data rate to buffer 124 is less than the fixed data rate of the BMT link, RCP 107 will effectively elevate the data rate by adding bits to the data stream before it is transmitted along wireline 109. These additional bits are inserted in a way that will not affect the information carried by the data stream (a practice commonly referred to as "bit stuffing"). Contrastingly, if controller 123 determines that the aggregate incoming data rate to buffer 124 is in

excess of the maximum BMT link data rate, the incoming data will be stored in buffer 124 as it arrives, and allowed to pass through to wireline 109 at a rate equal to the maximum BMT link data rate. This will of course result in an accumulation of information within buffer 124 as the data rate in is greater than the data rate out. The period over which RCP 107 can sustain such an uneven data flow is a function of the size of buffer 124 and the aggregate rate at which data continues to enter buffer 124.

If controller 123 determines that buffer 124 is in danger of becoming full (a condition that would result in the loss of any data subsequently transmitted to RCP 107 from base transceivers), it sends an IR signal to base transceiver or transceivers currently transmitting information to RCP 107 (in this case, base transceiver 101). This IR signal causes controller 122 within the base transceiver 101 to increase the bandwidth being used for error correction in communicating with field transceiver 116, thereby reducing the information bandwidth. This effectively diminishes the rate at which base transceiver 101 will transfer information to buffer 124, and allows for that buffer to be emptied. When controller 123 determines that buffer 124 is no longer in danger of becoming full, it will discontinue the IR signal being transmitted to base transceiver 101. Controller 122 will then be free to reduce the bandwidth devoted to error correction to a level suitable for the transmission environment.

After passing through buffer 124 107 and the BMT link, the signal from RCP 107 (which includes information as to the identity of field transceiver 116 and the particular data and AH/D being queried, as well as information reflecting the aggregate rate at which data is being collected by RCP 107, and the fullness of buffer 125) arrives at NGC 110 via wireline 112. NGC 110 depacketizes or demultiplexes the received signal, depending upon the encoding method employed by RCP 107, and routes the information contained in the signal to buffer 126. Controller 127 retrieves information relating to the identity of field transceiver 116 and AH/D 113 (the particular AH/D being queried) from the buffered signal and compares it to a listing of approved subscribers stored in database 128. If field transceiver 116 is found to be a subscriber approved to receive information from AH/D 113, controller 127 allows the request for information to be passed from buffer 126 to AH/D 113 at a fixed rate via wireline 114. This fixed rate is set by controller 127 as a function of stored information retrieved from database 128. Database 128 contains information regarding the particular data transmission capabilities of any and all AH/Ds connected to NGC 110. Controller 129 within AH/D 113, in response to the received request, retrieves the needed information from database 130, and transmits it at a fixed rate to buffer 131 via wireline 114. Controller 129 also embeds information as to the identity of the intended recipient of the information (field transmitter 116) into the data stream transmitted along wireline 114.

Controller 127 transfers the data received by buffer 131 to the link BMT via wireline 112. This data transfer must take place at the fixed rate required by the BMT link. As this fixed BMT rate is not necessarily equal to the rate at which AH/D 113 transfers data, buffer 131 is needed. If controller 127 determines that the incoming data rate to buffer 131 is less than the fixed data rate of the BMT link, NGC 110 will elevate the data rate by bit stuffing. Controller 127 may pause before allowing the data stored in buffer 131 to be transferred to the BMT link. This pause would be entered into if controller 127 had received a message indicating that buffer 125 of RCP 107 was nearly full (such information was included in the data requesting signal received from RCP 107). The pause may be for a fixed period or until controller 127 receives information from RCP 107 that buffer 125 was no longer in danger of becoming full. In any case, the data is transferred from the BMT link to buffer 125 via wireline 109.

Upon receipt of the data intended for field transceiver 117 being stored in buffer 125, controller 123 causes it to be transferred along information channel wireline 103 to base transceiver 101. The rate at which the data is transferred to base transceiver 101 is equal to the rate at which data was last received by RCP 107 from base transceiver 101. This data rate is commensurate with the error correction/information bandwidth ratio employed by field transceiver 116 in making the request for data. By returning data to base station 101 along information channel wireline 103 at this rate, a signal carrying the requested information may be readily transmitted back to transceiver 116 employing the same error correction/information bandwidth ratio -- A level of error correction suitable for the present transmission environment and overall system data load.

In the above transmission scenario, it was assumed that field transceiver 116 was transmitting in an area serviced by base transceiver 101. As multiple base transceivers may be employed within a wireless two-way messaging system, signals transmitted to and from a field transceiver may be received by different base transceivers (such as base transceiver 102) depending upon the location of a field transceiver. Base transceiver 102, which operates in manner similar to that of base transceiver 101, is shown in FIG. 1 to include controller 132 and T/R 133. The reception and passing of a received signal among various base transceivers can be managed in a fashion similar to that of a cellular telephone signal being passed from cell to cell. In addition, as multiple base transceivers can be employed, RCP 107 may simultaneously receive more than one signal originating from more than one field transceiver, or receive more than one signal from the BMT link intended for more

than one field transceiver. This additional information flowing through the system merely adds to the aggregate information flow and is compensated for through the buffering and information reduction processes described above.

FIG. 2 is a simplified block diagram showing a second wireless two-way messaging system incorporating components similar to those shown in FIG. 1. The system includes BMT 201 which is linked by wirelines 202, 203, 204 and 205 to RCPs 205, 206 and 207. Each of the RCPs is shown to be linked by control and information channel wirelines to two base transceivers, which are numbered 208 through 213. BMT 201 is also shown to be linked by wirelines 214, 215 and 216 to NGCs 217 and 218. Each of these NGCs is linked by wireline to two AD/Hs, numbered 219 through 222. In practicing a particular embodiment of the invention within the system of FIG. 2, communications are carried out between the base transceivers and various field transceivers (not shown). The field transceivers exchange information with the AH/Ds via radio transmissions, wirelines, base transceivers, NGCs and a BMT in a manner similar to that described for the system of FIG. 1.

The major difference in operation between the system of FIG. 2 and the system of FIG. 1 is an additional level of control facilitated by the control wirelines 223, 224 and 225. As shown, wirelines 223 and 224 connect all of the RCPs within the system together, thereby allowing the controllers within each of the RCPs to share information regarding the present level at which each is allowing data to be passed to wireline 202 for transmission to BMT 201. By allowing each of the RCPs to track the rate of information transmission of the other two RCPs, the aggregate data rate flowing along wireline 202 can be kept to a level matching the fixed data rate of BMT 201. To regulate this aggregate data rate, the buffers within each of RCPs employ variable buffering to allow the rate of data exiting each RCP to be varied somewhat independently of the rate at which data is received by a given RCP from any associated base transceivers (the buffering is performed in a manner similar to that described for RCP 107 of FIG. 1).

Control wireline 225 provides a link between NGC 217 and NGC 218. This link allows the controllers within the NGCs to share information regarding the level at which each is allowing data to be passed to BMT 210 via wireline 214. Each of the NGCs can then determine the aggregate rate at which data is flowing along wireline 214. By utilizing the buffers contained within each NGC, the controllers can regulate this aggregate data flow to matching the fixed data rate of BMT 201 (this inter-NGC buffering is performed in a manner similar to the buffering described for RCP 107 of FIG. 1). The inter-NGC buffering is performed in addition to the any other buffering or information reduction processes normally carried out within an NGC (such as those described above for NGC 110 of FIG. 1).

The above-described invention provides a practical technique for effecting variable error-correction wireless communications within a communication system, wherein the bandwidth dedicated to wireless signal error correction is varied in response to fading within the transmission environment, and the rate at which information is accumulating within the nodes of the communication system. It will be understood that the particular methods described are only illustrative of the principles of the present invention, and that various modifications could be made by those skilled in the art without departing from the scope and spirit of the present invention, which is limited only by the claims that follow. One such modification would include applying the method of this invention to a systems employing a wireline BMT link.

Claims

1. A method for transmitting information within a communication system comprising an endpoint node, an intermediate node and a distant node; said method comprising the steps of:

   transmitting information between said endpoint node and said intermediate node at a variable rate via an information channel, said variable rate being a function of the transmission quality afforded by said information channel;

   transmitting, from said intermediate node to said distant node, a signal indicating the present variable rate at which information is being transmitted between said endpoint node and said intermediate node; and

   transmitting information between said distant node and said intermediate node at a rate determined as a function of said present variable rate of transmission between said endpoint node and said intermediate node.

2. The method of claim 1 wherein said information transmitted between said distant node and said intermediate node is then transmitted from said intermediate node to said endpoint node at a rate equal to said present variable rate of transmission between said endpoint node and said intermediate node.

3. A method for transmitting information within a communication system comprising an endpoint node, an intermediate node and a distant node; said method comprising the steps of:

   transmitting information between said endpoint node and said intermediate node at a variable rate via a wireless information channel, said variable rate being a function of the trans-

mission quality afforded by said wireless information channel;

transmitting, from said intermediate node to said distant node, a signal indicating the present variable rate at which information is being transmitted between said endpoint node and said intermediate node; and

transmitting information between said distant node and said intermediate node at a rate determined as a function of said present variable rate of transmission between said endpoint node and said intermediate node.

4. The method of claim 1or3 wherein said rate determined as a function of said present variable rate of transmission between said endpoint node and said intermediate node is equal to said present variable rate of transmission between said endpoint node and said intermediate node.

5. The method of claim 3 wherein said information transmitted between said distant node and said intermediate node is then transmitted from said intermediate node to said endpoint node via a wireless information channel at a rate equal to said present variable rate of transmission between said endpoint node and said intermediate node.

6. A method for transmitting information within a communication system comprising:

a wireless field transceiver adapted to transmit and receive information via a first channel having a fixed bandwidth;

a base transceiver adapted to transmit information to, and receive information from said wireless field transceiver via said first channel, and

a remote data base adapted to transmit information to and receive information from said base transceiver via a second channel;

said method comprising the steps of:

transmitting information between said wireless field transceiver and said base transceiver at a variable rate via said first channel, said variable rate being a function of the transmission quality afforded by said first channel;

transmitting, from base transceiver to said remote data base, a signal indicating the present variable rate at which information is being transmitted between said wireless field transceiver and said base transceiver; and

transmitting information between said remote data base and said base transceiver, via said second channel, at a rate determined as a function of said present variable rate of transmission between said wireless field transceiver and said base transceiver.

7. The method of claim 6 wherein said rate determined as a function of said present variable rate of transmission between said wireless field transceiver and said base transceiver is equal to said present variable rate of transmission between said wireless field transceiver and said base transceiver.

8. The method of claim 6 wherein said information transmitted between said remote data base and said base transceiver is then transmitted from said base transceiver to said wireless field transceiver at a rate equal to said present variable rate of transmission between said remote data base and said base transceiver.

9. The method of claim 6 wherein said second channel includes a fixed rate information transmission channel.

10. A method for transmitting information within a communication system comprising:

a plurality of wireless field transceivers, each adapted to transmit and receive information via a separate channel having a fixed bandwidth;

a plurality of base transceivers, each adapted to transmit information to, and receive information from said plurality of wireless field transceivers via said separate channels, and

a plurality of remote data bases adapted to transmit information to and receive information from said plurality of base transceivers via a second channel, and further adapted to transmit information to each of said plurality of wireless field transceivers;

said method comprising the steps of:

transmitting information between at least one of said plurality of wireless field transceivers and at least one of said plurality of base transceivers, each of said transmissions being performed at a variable rate via one of said separate channels, wherein the particular variable rate of transmission for each of said separate channels is a function of the transmission quality afforded by each separate channel;

transmitting from at least one of said plurality of base transceivers to at least one of said plurality of remote data bases, via said second channel, a signal indicating the present variable rate at which information is being transmitted between each of said plurality of wireless field transceivers and said one of said plurality of base transceivers; and

transmitting information between at least one of said plurality of remote data bases and at least one of said plurality of base transceivers, at a rate determined as a function of said present variable rates of transmission between said plur-

ality of field transceivers and each of said base transceivers.

FIG. 1

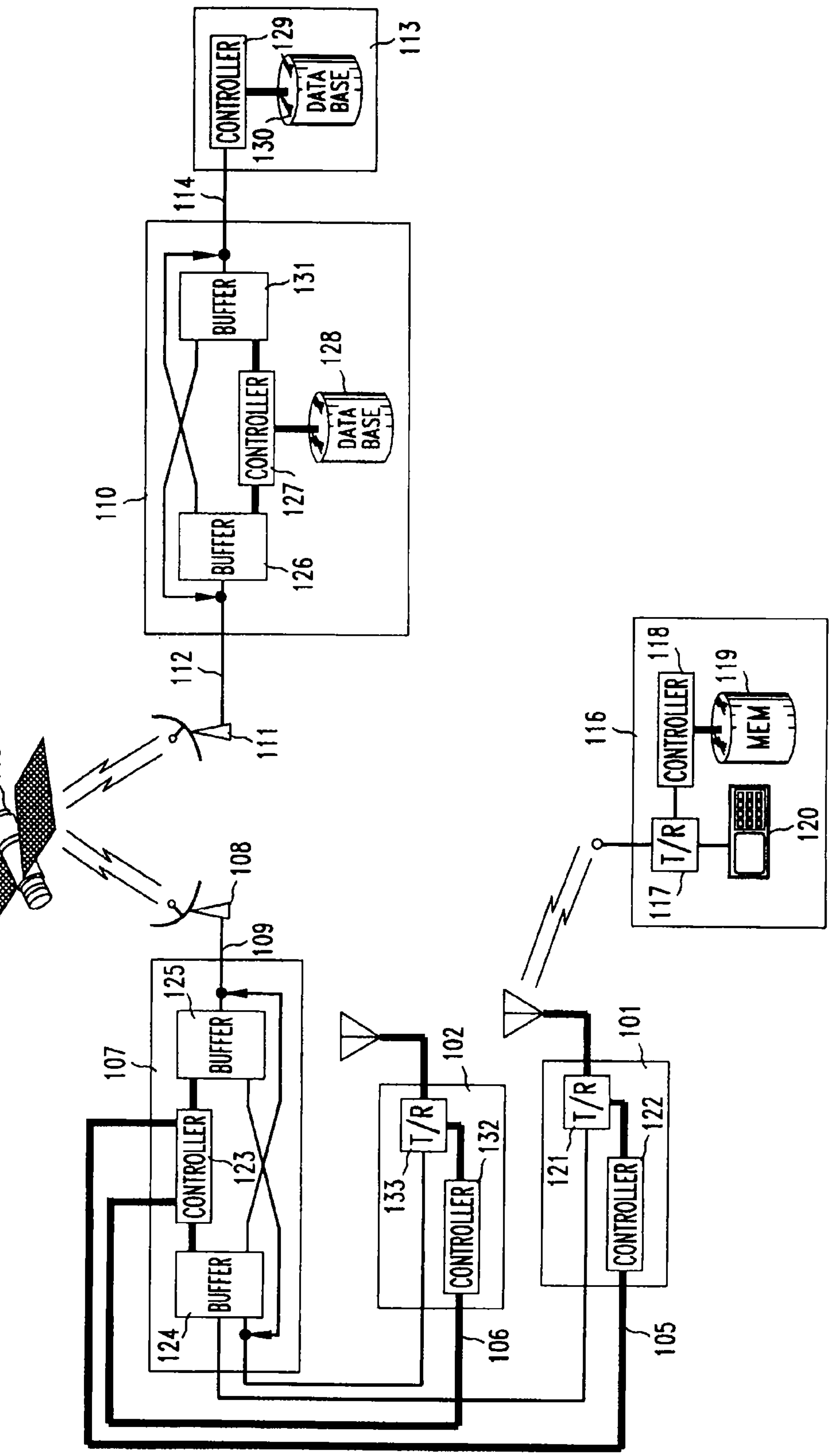
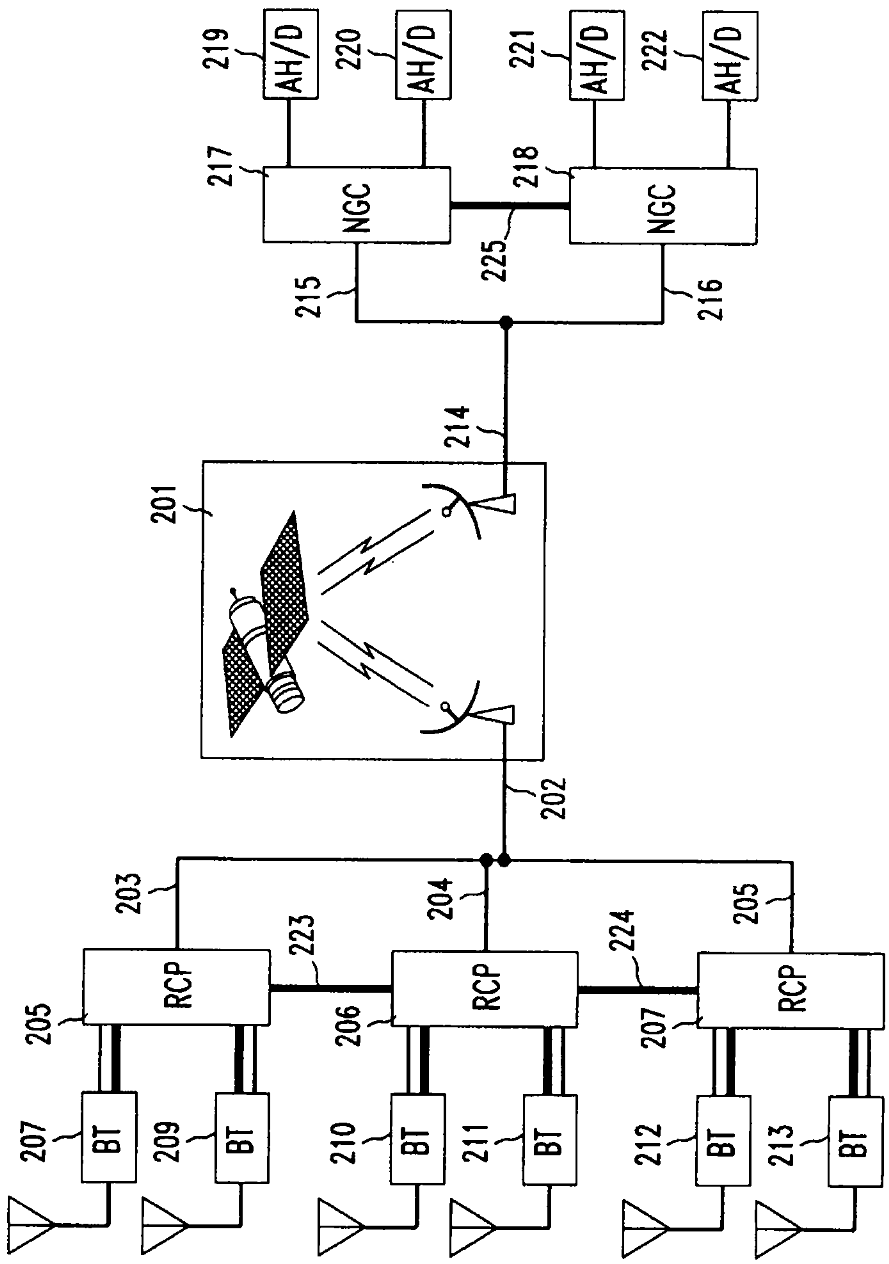

CONTROLLER
DATA BASE
BUFFER
T/R
MEM
101
102
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133

FIG. 2


AH/D
NGC
RCP
BT
201
202
203
204
205
206
207
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225

Doc Ref. **FP4**
Appl. No. 10/501,736

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 0 878 924 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.11.1998 Bulletin 1998/47

(51) Int. Cl.[6]: **H04B 7/26**

(21) Application number: **98108467.6**

(22) Date of filing: **08.05.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **12.05.1997 JP 121321/97**

(71) Applicants:
- **Sharp Kabushiki Kaisha**
  Osaka 545 (JP)
- **Hitachi, Ltd.**
  Chiyoda-ku, Tokyo 101-8010 (JP)
- **MITSUBISHI DENKI KABUSHIKI KAISHA**
  Tokyo 100-8310 (JP)
- **Communications Research Laboratory, Ministry of Posts and Telecommunications**
  Koganei-shi, Tokyo 184-8795 (JP)
- **Nippon Telegraph and Telephone Corporation**
  Tokyo 163-8019 (JP)
- **NTT MOBILE COMMUNICATIONS NETWORK INC.**
  Minato-ku, Tokyo 105-8436 (JP)
- **YRP Mobile Telecommunications Key Technology Research Laboratories Co., Ltd.**
  Yokosuka-shi, Kanagawa-ken 239-0847 (JP)

(72) Inventors:
- **Onodera, Tetsuo**
  Kitakatsushika-gun, Saitama 344-0115 (JP)
- **Usami, Hiroshi**
  Yokohama-shi, Kanagawa 245-0002 (JP)
- **Shibuya, Akihiro**
  Chiyoda-ku, Tokyo 100-8310 (JP)
- **Moriyama, Eimatus**
  Koganei-shi, Tokyo 184-0004 (JP)
- **Hamaguchi, Kiyoshi**
  Yokohama-shi, Kanagawa 234-0051 (JP)
- **Saito, Yoichi**
  Wakayama-shi, Wakayama 640-8412 (JP)
- **Matsumoto, Tadashi**
  Yokosuka-shi, Kanagawa 239-0846 (JP)
- **Mizuno, Mitsuhiko**
  Yokohama-shi, Kanagawa 221-0043 (JP)

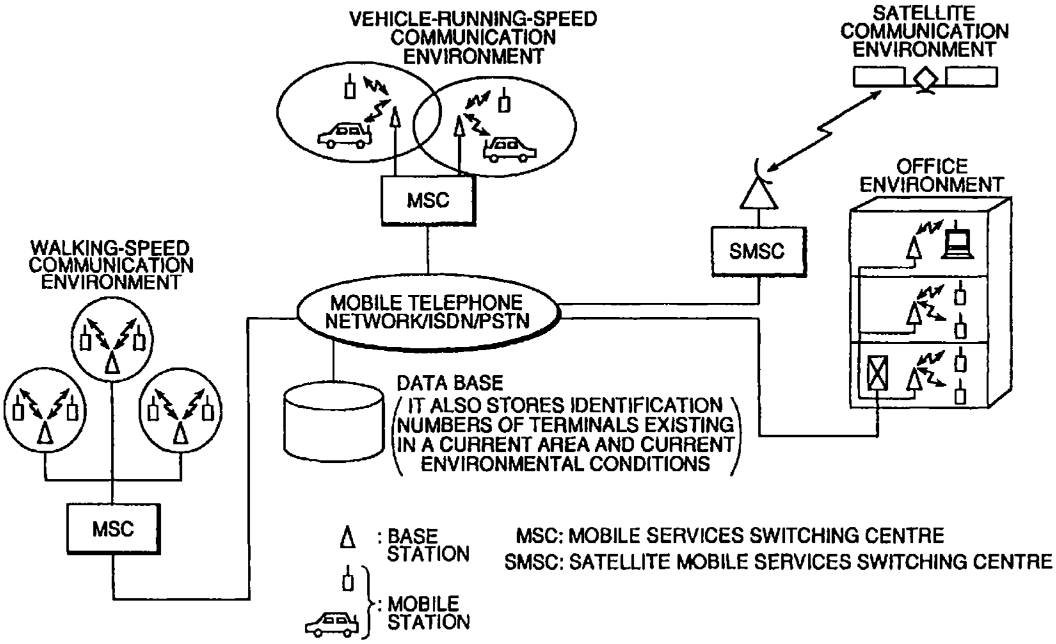
(74) Representative:
Müller, Frithjof E., Dipl.-Ing.
Patentanwälte
MÜLLER & HOFFMANN,
Innere Wiener Strasse 17
81667 München (DE)

(54) **Time-division multiple-access communication system**

(57) The present invention is directed to a TDMA communication system which is adapted to different communication environments or prepares different communication environments and allows each mobile station to be set for working in any one of the different communication environments. This enables the mobile terminal to conduct communications in different communication environments and at different transmission rates. An office communication environment, a walking-speed mobile-communication environment, a vehicle-running-speed mobile-communication environment and a satellite communication environment are separately constructed and connected to each other by a communication network. Each environment system has a mobile exchanging function, a base-station function with a transmitter-receiver and mobile-station function with a transmitter-receiver to realize communication therein. The communication system commonly uses a TDMA format that has a fixed frame-length and a constant number of bits for each of the slots composing the frame. The communication environments have prepared respective sets of communication conditions, each set including a transmission power, a modulating method, the number of multiplexed signals, error-correction, an antenna gain, a frequency hopping value and a diversity value. At each mobile station and each base station, one of plural sets of communication conditions for respective environments is selected to establish communication with each other under the selected environment.

EP 0 878 924 A2

FIG.1


VEHICLE-RUNNING-SPEED COMMUNICATION ENVIRONMENT
SATELLITE COMMUNICATION ENVIRONMENT
OFFICE ENVIRONMENT
MSC
SMSC
WALKING-SPEED COMMUNICATION ENVIRONMENT
MOBILE TELEPHONE NETWORK/ISDN/PSTN
DATA BASE
(IT ALSO STORES IDENTIFICATION NUMBERS OF TERMINALS EXISTING IN A CURRENT AREA AND CURRENT ENVIRONMENTAL CONDITIONS)
MSC
: BASE STATION
: MOBILE STATION
MSC: MOBILE SERVICES SWITCHING CENTRE
SMSC: SATELLITE MOBILE SERVICES SWITCHING CENTRE

Description

BACKGROUND OF THE INVENTION

The present invention relates to a communication system using a TDMA (Time-Division Multiple-Access) method and more particularly to a communication system which adapts to different communication environments or provides different communication environments for transmitting and receiving signals.

The highly-advanced information technology era has brought with it the increasing demand for systems and devices allowing users to conduct wireless (radio communication) telephone or data-communications in a variety of situations, e.g., during walking outdoor or moving on a vehicle or working in an office. The present rapid development of infrastructures for various kinds of communication systems such as telecommunications with cordless telephones, portable telephones and local-area networks (LAN) radio-communications makes it possible for any one to communicate with any other person any time at any place.

However, many infrastructures have incompatible systems that require the use of specially designed terminals, preventing terminals from being used in common between the systems. For example, two representatives of TDMA communication systems, i.e., Personal Digital Cellular system (PDC) and Personal Handy-phone system (PHS) are incompatible and use different radio-frequencies, transmission power values, a number of slots per frame, bit rates, methods for coding and decoding audio signals and so on.

The incompatibility of the communications systems requires users to use different devices (PHS, PDC, Pagers and so on) specially designed for respective systems to make wireless (radio communication) telephone or data-communications during walking or from a vehicle or from an office. This is inconvenience for users. A terminal that can realize functions of two different systems may be manufactured with an increased dimension because it must contain many processing circuits that cannot be commonly used.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to provide a TDMA communication system which adapts to different communication environments or prepares different communication environments for communications between mobile stations and base stations and allows each mobile terminal to conduct radio-communication at different transmission rates under different environments.

(1) An object of the present invention is to provide a TDMA communication system for executing communications between mobile stations and a base station using a TDMA method, wherein a TDMA format that has a constant time of a frame length and a constant number of bits in each of slots composing a frame is used as a common-use communication data format and each of the mobile and base stations is provided each with a communication device for processing communication signals based on the TDMA format, which device can operate in any one of plural different Communication environments designated by selecting a corresponding one of prepared sets of environmental communication conditions each including a transmission power value, a modulation method, the number of multiplexed signals and an error-correction method.

(2) Another object of the present invention is to provide a TDMA communication system as mentioned (1) above, which is characterized in that communications between the mobile stations and the base station are made by means of radio communication in a selected communication environment with the prepared conditions including additional conditions such as an antenna gain, a diversity method and frequency hopping.

(3) Another object of the present invention is to provide a TDMA communication system as mentioned (1) or (2) above, which is characterized in that priority of the different communication environment conditions are registered in a data base allowing the communication devices to select one of the communication environments according to the preset priority.

(4) Another object of the present invention is to provide a TDMA communication system as mentioned any one of (1) to (3) above, which is characterized in that the plural sets of different communication environment conditions are prepared for at least two of different environments comprising an office communication environment, a walking-speed communication environment, a mobile-running-speed communication environment and a satellite communication environment.

(5) Another object of the present invention is to provide a TDMA communication system as mentioned any one of (1) to (4) above, which is characterized in that the base station generates individually each set of the communication environment conditions and broadcasts the generated environmental information and each mobile station receives the broadcasted information and automatically selects a corresponding one of the prepared sets of the communication conditions according to the received information of communication-environment conditions.

(6) Another object of the present invention is to provide a TDMA communication system as mentioned any one of

(1) to (4) above, which is characterized in that any of the prepared sets of the communication conditions can be manually selected and set.

(7) Another object of the present invention is to provide a TDMA communication system as mentioned any one of (1) to (6) above, which is characterized in that equalizing means with an adaptive equalization mode being changed according to a selected one of the communication environments are additionally provided for improving a bit error rate in a fading channel.

(8) Another object of the present invention is to provide a TDMA communication system as mentioned any one of (1) to (7) above, which is characterized in that the system is provided with a data base for controlling whole communication environments of mobile stations communicating with other mobile stations through the base station over a radio channel established between them and the data base is adaptable to changing channel connections from one environment to another different environment.

(9) Another object of the present invention is to provide a TDMA communication system as mentioned any one of (1) to (8) above, which is characterized in that the TDMA format is a format that can be commonly used by a personal handy-phone system (PHS).

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is illustrative of a structure of a whole TDMA communication system embodying the present invention.

FIG. 2 is a construction diagram of a transmitter-receiver which is a component of the TDMA communication system according to the present invention.

FIG. 3 is illustrative of an exemplified structure of a TDMA frame and slots, which is used in a TDMA communication system according to the present invention.

FIG. 4 depicts an example of specifications on respective environments created by the TDMA communication system according to the present invention.

FIG. 5 depicts an example of a unique word pattern in construction of slots shown in FIG. 3.

FIG. 6 depicts an example of BER characteristics obtained by an array combining type adaptive equalizer used for 16QAM.

PREFERRED EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention will be described below in detail with reference to accompanying drawings.

Fig. 1 depicts a structure of a TDMA communication system according to the present invention.

As shown in Fig. 1, the system provides respective communication environments such as an office communication environment, a walking-speed mobile communication environment, a vehicle-running-speed mobile communication environment and a satellite communication environment, all of which are connected with each other through a communication network. There is shown an example of the TDMA communication system wherein the system of the vehicle-running-speed environment includes the system of the walking-speed environment with mobile stations (i.e., the latter system without any modification of the preset conditions can be a component of the former system).

The system according to each of the communication environments has a mobile-exchange function, a base-station function and a mobile-station function as its components. Each base station and each mobile station have a transmitter-receiver set for executing the system operations.

The communication network interconnecting the system in respective communication environment includes a data base containing records and certificates of identification numbers of mobile terminals existing within the service area, the current conditions of environment for the terminals, classes of the terminals, and so on. Accordingly, each mobile terminal can adapt to each communication environment when moving from one environment to another different environment.

Fig. 2 depicts an exemplified structure of a transmitter-receiver of a mobile station that is a component of the TDMA communication system according to the present invention.

The transmitter-receiver is provided with a channel coding portion (including an error-detection/correction coding portion) 11 for encoding information signals from a sound encoding/decoding codec (not shown) and a data portion (not shown), an quadrature modulating portion 12, a transmission-frequency converting portion 13, a transmission-power control portion 14, a frequency synthesizing portion 34, a clock-pulse generating portion 33, a received-frequency converting portion 26, an quadrature detecting (demodulating) portion 25, a diversity combining portion 24, an adaptive equalizing portion 23, discriminating portion 22, a channel decoding portion (including an error-detection/correction portion) 21, an environment estimating and selecting portion 31 and a control portion 32.

In the transmitter side, the channel coding portion 11 encodes an information signal to form required TDMA frames in accordance with the channel. The quadrature modulator portion 12 orthogonally modulates the coded signal. Then

the transmission-frequency converting portion 13 through the frequency synthesizing portion 34 converts the modulated signal into a required radio-frequency signal to be transmitted over the network. The transmission-power control portion 14 controls transmission power of the radio-frequency signal.

On the other hand, in the receiver side, a radio-frequency signal is received through an antenna and is converted by the received-frequency converting portion 26 with the frequency synthesizing potion 34 to a signal that can be subject to baseband processing. The converted signal is orthogonally demodulated by the quadrature demodulating portion 25.

In the shown embodiment, there are pairs of the received-signal converting portion 26 with the quadrature detecting (demodulating) portion 25, either one pair that yields a communication route with the better quality signal is selected by the diversity combining portion 24. The adaptive equalizing portion 23 equalizes a waveform of the signal and the discriminating portion 22 outputs a binary digital signal. The channel decoding portion 21 decodes the digital signal to obtain a necessary information signal.

The control portion 32 controls the operations of the portions and the whole communication system at predetermined timing using timing pulses generated from the clock-pulse generating portion 33.

The environment estimating and selecting portion 31 generates a signal for setting one of communication environments based on a manual selection of the predetermined conditions, automatic selection of information from the base station or estimation of the transmission channel (route). According to the signal outputted from the environment estimating and selecting portion 31, the control portion 32 selects a modulating method by changing the signal point for channel coding, selects an error-detection/correction method for the channel coding portion 11 and the channel decoding portion 21 and changes a number of multiplexing signals by changing a frequency dividing ratio of the clock-pulse generating portion 33. The control portion 32 can control the transmission power control portion 14 to control a transmission-power value and the adaptive equalizing portion 23 to select an adaptive equalizing method. The control portion 32 can also control the frequency hopping by changing a preset value of the frequency synthesizer 34 and controls the diversity selecting portion 24 to select a diversity route.

The following description relates to a frame structure according to a TDMA format which is used as a data communication format featuring the TDMA communication system of the present invention.

Fig. 3 shows an exemplified structure of a TDMA frame to be used in the channel coding portion 11 shown in Fig. 2. The frame has a constant frame length, a variable number of multiplexed slots and a variable modulation method, which is adaptable to use in different environments or at different user rates.

As shown in Fig. 3, a frame-structure Fr having a constant frame length of 10 ms and is composed basically of slots for control (control slots) of down BCCH Sc1 and up/down SCCH Sc2 respectively and slot for communication (communication slot) TCH Si.

Communication environments are prepared with conditions preset at the base station. The transmitter-receiver terminal of each mobile station can be adaptable to any one of the prepared environments, which is selected by connecting a channel in an environment selected from a variable range of digital modulation method QPSK/16QAM at the quadrature modulator portion 12 and the multiplexing number of 4 to 64 according to a user rate of 128 kbps to 4.096 Mbps and a constant number of bits in each slot. In Fig. 3, a ramp bit is denoted by character R, a preamble PR, a unique word UW, channel identifier CI, a control bit C, an information bit I, a CRC check Bit CRC and guard bit G.

The number of bits in every slot is 480 (constant) A basic service rate signal 2B + D of the ISDN (Integrated Service Digital Network) can be easily transmitted by setting an I-to-C ratio in the communication slot Si at 8:1 and by making a user information transmitting portion 2B (2B= 64 kbps × 2 = 128 kbps) and a control information transmitting portion D (D= 16 kbps) correspond to I and C respectively.

Fig. 5 shows an example of the unique word in the slot structure shown in Fig. 3.

Fig. 4 shows an exemplified technical specification of respective environments in which the TDMA communication system according to the present invention must work.

The operation of the TDMA communication system according to the present invention, which includes the mobile station provided with the transmitter-receiver and working with the TDMA format frame in respective environments having the specifications shown in Fig. 4, will be described below:

As shown in Fig. 4, an environment P (walking) provides 64 slots per frame (10 ms) at a maximum user rate of 2.048 Mbps and adopts a modulating method QPSK while an environment V provides 4 slots per frame (10 ms) at a maximum user rate of 128 kbps and adopts the modulating method QPSK.

It is possible to use the processing circuit of the system in common for different user-information transmitting rates by changing the number of slots per frame at a constant number (480) of bits per slot. This can be realized by changing the clock of the hardware depending on a user-information transmitting rate.

Although the above embodiment is described with the frame length of 10 ms, it can also work at the frame-length of, e.g., 5 ms to ensure compatibility of the system with PHS (Personal Handy Phone System e.g. RCR-STD 28). Accordingly, application of the method according to the present invention can facilitate miniaturizing the terminal devices.

On the other hand, a bit rate of carriers used for communication between the base station and the mobile station varies depending on the user-information transmitting rate as shown in Fig. 4.

Different radii of service areas and different maximal rates of information transmission must be realized depending upon different communication environments (i.e., an office environment, a walking-speed environment, a vehicle running-speed environment, a satellite environment, and so on). Therefore, each base station is provided with equipment that has different transmission power values, antenna gains and carrier bit rates in accordance with the different environments.

The base station has a broadcasting channel (BCCH) for always broadcasting control information at different carrier bite rates. The mobile station can previously know a transmission frequency, a carrier bit rate and a modulating method of signals from the base station.

The mobile station receives control information over the broadcasting channel (BCCH) and is placed under the control of the system constructed on the conditions indicated by the control information. The control information of the BCCH contains other information for the mobile station other than the carrier bit rate and the modulating method.

Accordingly, the mobile station can know a possible communication mode from the BCCH received from a certain base station. The user at a mobile terminal (station) can select a desired communication environment, i.e., a base station which provides the desired environment. The mobile station can also know which environments (i.e., base stations) are possible to use by scanning the broadcast channels from base stations existing in the service area where the mobile station moves.

With the user's request, the mobile station can automatically select in a programmed procedure a base station where it is waiting for connection with another mobile station. The above-mentioned function for selecting a base station can be realized by previously registering the priority of base stations producing different communication environments and by selecting a suitable one according to the registered priority.

The location of the mobile station is registered in the selected base station wherein the mobile station is in waiting state.

TDMA/TDD (Time Division Duplex) system provides operation modes to be used for communication may have a very high correlation of propagation state between an uplink and a downlink when the frame length is sufficiently short. Therefore, the system can adopt an adaptive modulation method that changes a modulation method and a bit rate per slot instantly with the change in the transmission state by estimating instant CNR and a spread of a phase lag (refered to Technical Report of IEICE RCS94-64).

Generally, an initial call negotiation between a base station and a mobile station determines the operating mode for communication, in which the base station and the mobile station work at a constant modulation method and a constant bit rate while the call is maintained therebetween.

The required CNR/CIR value must be reduced since they may have a considerable influence on a bit rate, a cell radius and a required transmission power.

The reduction of the required CNR/CIR value in the TDMA communication system according to the present invention can be realized by applying any one of the following known methods:

- High-speed transmission at a time from a plurality of stations (4-branch diversity):

This method enables transmission with a transmission power of 10 W at a bit rate of 1 Mbps in a cell having a radius of not less than 2 km. (Tomisato and Suzuki, "A High-speed digital mobile radio communication system by using multi-transmitter signal transmission", 1995, IEICE society symposium B-386)

- Interference canceling equalization (ICE) for improvement of CIR

This method can expand the system capacity for accommodating subscribers twice as much as PDC by making common use of the same frequency by two users in the same sector. (Suzuki and Hirade, "Capacity increase of TDMA mobile communication systems enhanced with interference cancelling equalizers (ICE)", 1995, IEICE society symposium B-276)

- Dynamic channel allocation

The simulation test results show that the efficiency of using frequencies is increased by dynamic channel allocation rather than fixed channel allocation, for example, 2.5 to 3 times by an ACCA method and 2 times by a segregation method.

(郵政省「インテリジェント電波利用に関する調査研究会最終報告書」平成6年4月：

The Ministry of Posts and Telecommunications, "Final report on research and study of an intelligent radio-wave-utilization", April. 1994)

• Adaptive modulation

A system capacity can be increased by adaptively changing a QPSK/16QAM rate in the range from 1 to 1/8 according to CIR values at the periphery and the center of a cell.
(Sampei et. al. "An analysis on the performance of variable symbol rate and modulation level adaptive modulation system", Technical report of IEICE. RCS94-64 (1994-09))

The adaptive equalizing portion 23 in the example of the transmitter-receiver of Fig. 2 can use the following types of equalizers:

An adaptive equalizer used in QPSK may be, for example, a combined type diversity decision feed back equalizer (DFE) that is featured by a saved capacity of its memory necessary for amount of operations and signal processing. (Shirato et. al., "A Combining Diversity DFE with Mode-switching", 1996, IEICE societysymposium B-463)

An adaptive equalizer used in 16QAM may be a known type equalizer that has, by way of example, attained data shown in Fig. 6. Fig. 4 shows, by way of example, technical data of the system in which these means (including the array combining adaptive equalization) are applied, which data includes a cell radius, a transmission power, an antenna gain, a modulation method, a required CNR, a carrier bit rate, a user rate.

On-Off control of the adaptive equalizers to save the power consumption of the system may be realized in such a way that CRC and RSSI (Received signal strength indication) are checked and the equalizer is turned on only if an error occurs with an intensive signal.

Although the TDMA communication system according to the present invention was described above by way of an example with radio communication, the present invention is not restricted thereto and can be of-course applied to cable communication, e.g., a fiber optics communication system if it allows terminal stations to work by selecting one of different communication environments.

Advantageous effects according to the present invention as follows:

(1) In the TDMA communication system according to the present invention, each mobile terminal to conduct communications in a plurality of different environments or at different transmission rates, thus eliminating the need for using different mobile terminals for respective different infrastructures as conventional systems require.

(2) In addition to the advantageous effect of (1) mentioned above, an optimal mobile communication system can be constructed by using radio frequency as means for transmitting data signals.

(3) In addition to the advantageous effect of (1) or (2) mentioned above, different communication environments overlaid in areas can be selected in an order of priority, thus making it possible to control usable links at increased efficiency.

(4) In addition to the advantageous effect any one of (1) to (3) mentioned above, each mobile terminal can work in any one of the different communication environments such as an office environment, a walking-speed environment, a vehicle running-speed environment and a satellite environment.

(5) In addition to the advantageous effect any one of (1) to (4) mentioned above, connection of a channel between a mobile terminal and a base station is automatically conducted by each mobile terminal that receives broadcast data of generated communication environments from the base station and sets corresponding conditions according to the received data to connect itself to the base station.

(6) In addition to the advantageous effect any one of (1) to (4) mentioned above, each mobile terminal can be selectively set by hand to conditions necessary for communication with a base station, thus realizing simple construction of the terminal in comparison with that of the terminal of claim 4. This also enables the terminal to be faster connected to the base station.

(7) In addition to the advantageous effect any one of (1) to (6) mentioned above, a bit-error-rate in a fading channel can be improved, thus increasing the accuracy of communications.

(8) In addition to the advantageous effect any one of (1) to (7) mentioned above, each mobile terminal can continue

the communication when it moves from one area into another area of different communication environment.

(9) In addition to the advantageous effect of any one of (1) to (8) mentioned above, the communication system ensure compatibility with PHS.

Claims

1. A TDMA (Time Division Multiple Access) communication system for communicating between mobile stations and a base station using a TDMA method, characterized in that a TDMA format that has a constant time of a frame length and a constant number of bits in each of slots composing a frame is used as a common-use communication data format and the mobile stations and the base station is provided each with a communication device for processing communication signals based on the TDMA format, which device can operate in any one of a plurality of different communication environments designated by selecting a corresponding one of prepared sets of communication environment conditions each including a transmission power value, a modulation method, the number of multiplexed signals and an error-correction method.

2. A TDMA communication system as defined in claim 1, characterized in that communications between the mobile stations and the base station are made by means of radio communication in a selected communication environment with the prepared communication environment conditions including additional conditions such as an antenna gain, a diversity method and frequency hopping.

3. A TDMA communication system as defined in claim 1 or 2, characterized in that priority of the different communication environment conditions are registered in a data base allowing the communication devices to select one of the communication environments according to the preset priority.

4. A TDMA communication system as defined in any one of claims 1 to 3, characterized in that the plural sets of different communication environment conditions are prepared for at least two of different environments comprising an office communication environment, a walking-speed communication environment, a mobile-running-speed communication environment and a satellite communication environment.

5. A TDMA communication system as defined in any one of claims 1 to 4, characterized in that the base station generates individually each set of the communication environment conditions and broadcasts information concerning to the generated communication environment conditions and each mobile station receives the broadcasted information and automatically selects a corresponding one of the prepared sets of the communication conditions according to the received information concerning to communication environment conditions.

6. A TDMA communication system as defined in any one of claims 1 to 4, characterized in that any of the prepared sets of the communication conditions can be manually selected and set.

7. A TDMA communication system as defined in any one of claims 1 to 6, characterized in that an equalizer (23) with an adaptive equalization mode being changed according to a selected one of the communication environments are additionally provided for improving a bit error rate in a fading channel.

8. A TDMA communication system as defined in any one of claims 1 to 7, characterized in that the system is provided with a data base for controlling whole communication environments of mobile stations and the data base is adaptable to changing channel connections from one environment to another different environment.

9. A TDMA communication system as defined in any one of claims 1 to 8, characterized in that the TDMA format is a format that can be used in common with a personal handy-phone system.

FIG.1

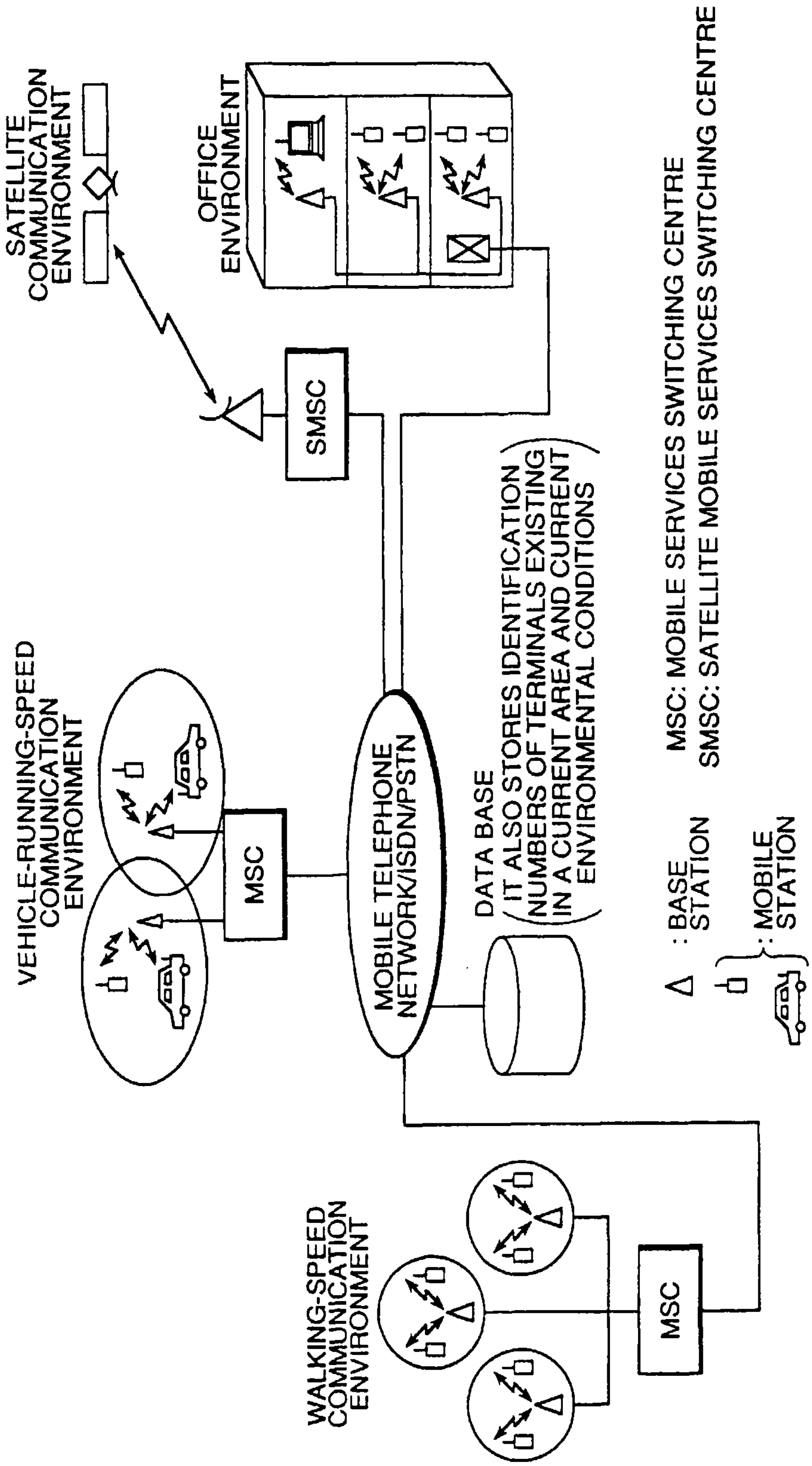

WALKING-SPEED COMMUNICATION ENVIRONMENT
MSC
VEHICLE-RUNNING-SPEED COMMUNICATION ENVIRONMENT
MSC
MOBILE TELEPHONE NETWORK/ISDN/PSTN
DATA BASE
(IT ALSO STORES IDENTIFICATION NUMBERS OF TERMINALS EXISTING IN A CURRENT AREA AND CURRENT ENVIRONMENTAL CONDITIONS)
SMSC
SATELLITE COMMUNICATION ENVIRONMENT
OFFICE ENVIRONMENT
: BASE STATION
: MOBILE STATION
MSC: MOBILE SERVICES SWITCHING CENTRE
SMSC: SATELLITE MOBILE SERVICES SWITCHING CENTRE

FIG.2

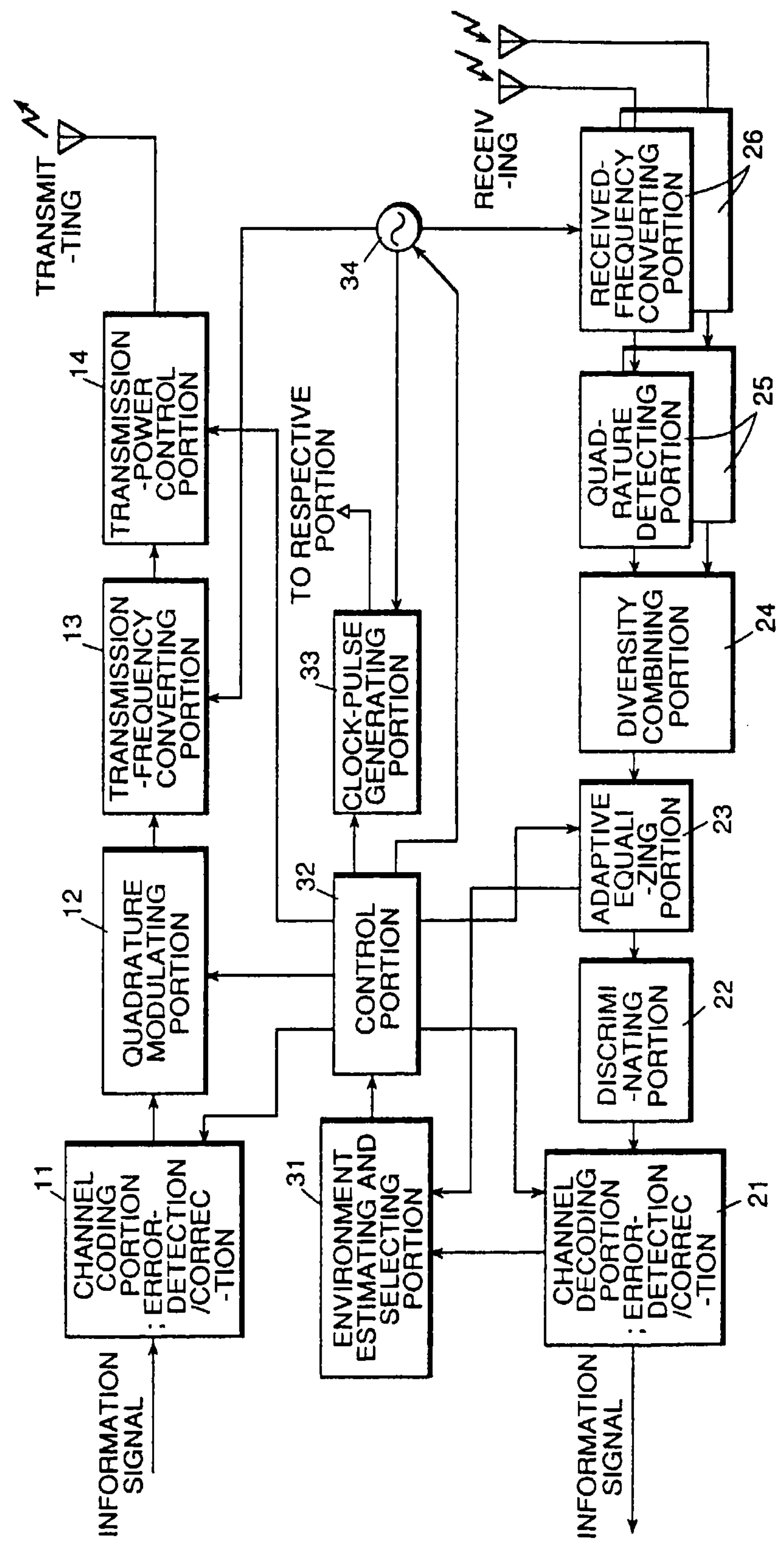

INFORMATION SIGNAL
CHANNEL CODING PORTION ; ERROR-DETECTION /CORREC -TION
11
QUADRATURE MODULATING PORTION
12
TRANSMISSION -FREQUENCY CONVERTING PORTION
13
TRANSMISSION -POWER CONTROL PORTION
14
TRANSMIT -TING
ENVIRONMENT ESTIMATING AND SELECTING PORTION
31
CONTROL PORTION
32
CLOCK-PULSE GENERATING PORTION
33
TO RESPECTIVE PORTION
34
RECEIV -ING
INFORMATION SIGNAL
CHANNEL DECODING PORTION ; ERROR-DETECTION /CORREC -TION
21
DISCRIMI -NATING PORTION
22
ADAPTIVE EQUALI -ZING PORTION
23
DIVERSITY COMBINING PORTION
24
QUAD- RATURE DETECTING PORTION
25
RECEIVED- FREQUENCY CONVERTING PORTION
26

FIG.3

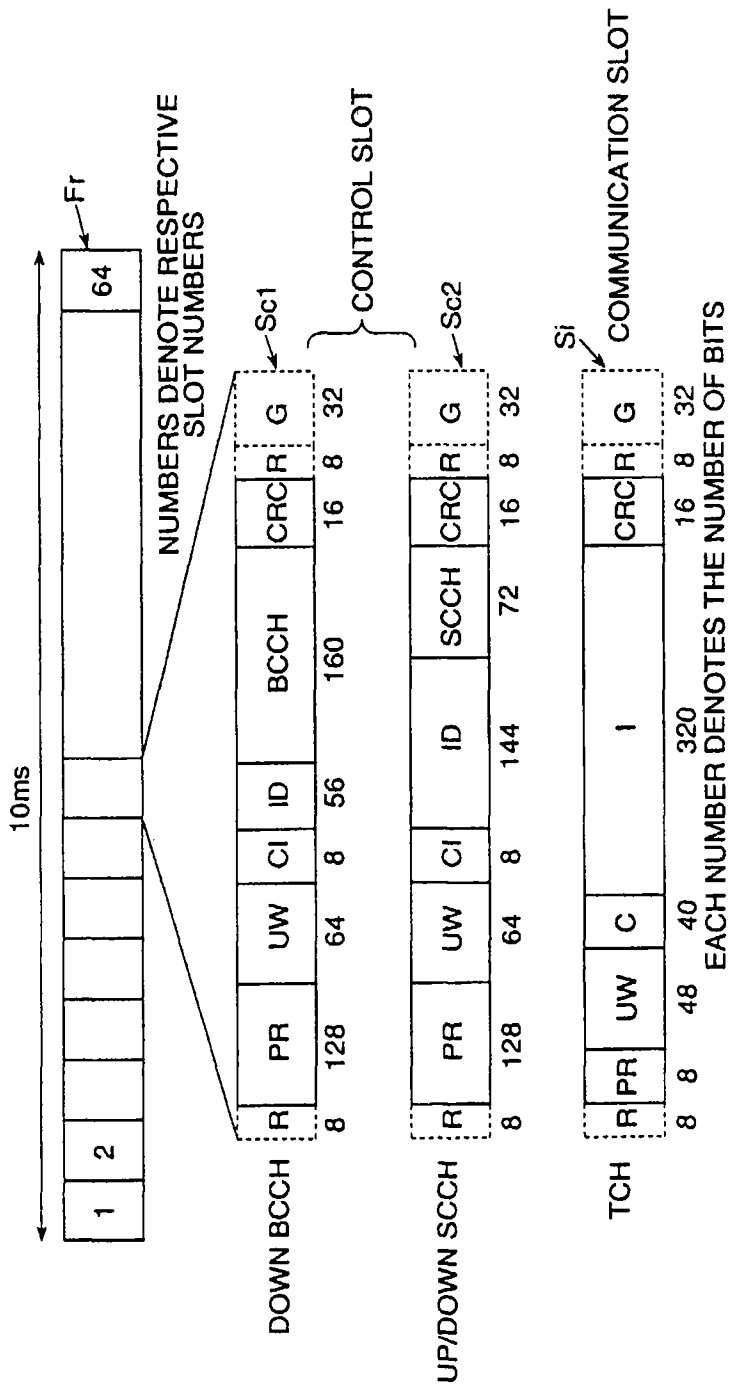

10ms
1
2
64
Fr
NUMBERS DENOTE RESPECTIVE SLOT NUMBERS
DOWN BCCH
R
PR
UW
CI
ID
BCCH
CRC
R
G
8
128
64
8
56
160
16
8
32
Sc1
CONTROL SLOT
UP/DOWN SCCH
R
PR
UW
CI
ID
SCCH
CRC
R
G
8
128
64
8
144
72
16
8
32
Sc2
TCH
R
PR
UW
C
I
CRC
R
G
8
8
48
40
320
16
8
32
Si
COMMUNICATION SLOT
EACH NUMBER DENOTES THE NUMBER OF BITS

FIG.4

ENVIRON-MENTS		CELL RADIUS	TRANSMIS-SION POWER (PEAK)	ANTENNA GAIN (BS/MS)	MODU-LATING METHOD	REQUIRED CNR (NOTE 1)	CARRIER BIT RATE	USER RATE	SERVICE RATE
ENVIRON-MENT O (OFFICE)		30m	80mW	10dB/-6dB	16QAM	29dB	6.144Mbps	4.096Mbps	PRIMARY GROUP INTERFACE×2
ENVIRON-MENT P (WALKING)		400m	800mW	10dB/-6dB	QPSK	10dB	3.072Mbps	2.048Mbps	PRIMARY GROUP INTERFACE
ENVIRONMENT V (VEHICLE)	SHORT MACRO	1.15km	1.5W	16dB/-6dB	16QAM	21dB	768kbps	512kbps	(2B+D)×4
		3km		16dB/-6dB	QPSK	10dB	384kbps (NOTE 2)	256kbps	(2B+D)×2
	LONG MACRO	10km		16dB/-0dB	QPSK	10dB	192kbps (NOTE 2)	128kbps	2B+D

NOTE 1 : ARRAY COMBINING ADAPTIVE EQUALIZATION IS ADAPTED AS A TECHNIQUE FOR REDUCING CNR

NOTE 2 : MULTI-CARRIER IS ALSO CONSIDERED

FIG.5

PATTERN UW

- CONTROL SLOT : "1" IS ADDED TO A PN PATTERN OBTAINED BY THE FOLLOWING PRIMITIVE POLYNOMIALS

  UP X^6+X+1 (INITIAL VALUE : 04octal representation)

  DOWN X^6+X^5+1 (INITIAL VALUE : 07octal representation)

- COMMUNICATION SLOT: 48 BITS SELECTED FROM THE PN PATTERN

		---- UW PATTERN ----
UP	I - CH	010010011100010111100101
INITIAL VALUE : 12(octal)	Q - CH	010000011111101010110011

		---- UW PATTERN ----
DOWN	I - CH	010100111101000111001001
INITIAL VALUE : 64(octal)	Q - CH	110011010101111110000010

FIG.6